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Economic Analysis of Erosion and Sedimentation
UPPER EMBARRAS RIVER BASIN

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PREFACE

This is the sixth and final report in a series of watershed studies conducted under a research project funded by the Illinois Institute of Environmental Quality. The project, "Soil Loss from Illinois Farms: Economic Analysis of Productivity, Loss, and Sediment Damage," was initiated in July, 1972. Previous studies of the economics of soil conservation have emphasized the loss of soil productivity resulting from erosion. In this series of reports the damage caused by sedimentation is also considered. In this watershed study, as well as in the others in this series, we attempt to improve our judgment about the magnitude and importance of the erosion-sedimentation problem and also to provide a basis for improved decision-making at both the state and local levels.

We gratefully acknowledge the contribution of our Advisory Committee in the conduct of the project. This committee consisted of Robert G. Baker, Lerna; William C. Bodman, Bement; L.D. Carmichael, Rochelle; Gerald Glasco, Marion; and Virgil Kleinlein, Mt. Sterling. William Kuenstler furnished valuable assistance in soil mapping and collecting soil and crop management information. W.D. Seitz and Karl Guntermann contributed to the initial planning phases of the project and to the analysis of the watershed studies. The authors, of course, bear the responsibility for any errors of fact and interpretation.

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April, 1975

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Economic Analysis of Erosion and Sedimentation
UPPER EMBARRAS RIVER BASIN

M.T. Lee, A.S. Narayanan, and E.R. Swanson

The Upper Embarras River Basin (UERB) is defined as a drainage area upstream of roughly the boundary of Coles and Cumberland Counties. It covers about 896 square miles in Champaign, Douglas, Coles, Edgar, and Cumberland Counties. The outlet of this watershed is currently under investigation as a possible site for a flood control reservoir. The major problem is periodic inundation in the downstream area. The runoff problem was studied by the U.S. Army Corps of Engineers [13]. However, the erosion and sedimentation problem was not investigated intensively. Drawing upon experience gained from previous watershed studies [4, 5, 7, and 8], we have undertaken in this report to study the economic aspects of erosion and sedimentation in this typical watershed located in the flat, productive farmland of central Illinois.

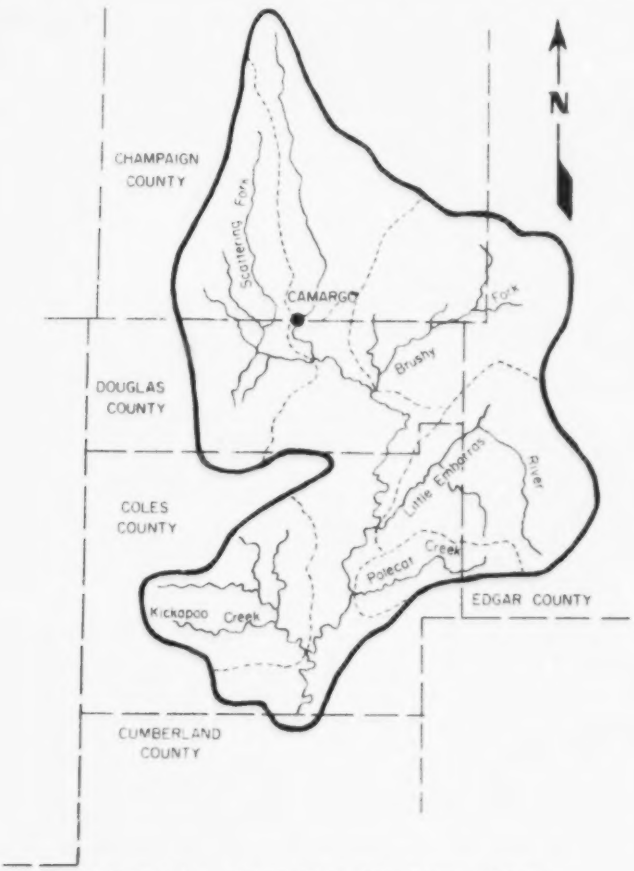

Figure 1. Upper Embarras River Basin.

M.T. Lee and A.S. Narayanan are Research Associates, Department of Agricultural Economics, and E.R. Swanson is Professor, Department of Agricultural Economics. All authors are faculty members of the University of Illinois at Urbana-Champaign.

For this analysis we divided the entire watershed into seven subwatersheds (Fig. 1 and Table 1): (1) the Embarras River Direct Tributary (ERDT) (134,455 acres), (2) the Embarras River above Camargo (ERC) (109,131 acres), (3) Scattering Fork (SF) (71,034 acres), (4) Brushy Fork (BF) (89,799 acres), (5) the Little Embarras River (LER) (84,600 acres), (6) Polecat Creek (PC) (17,157 acres), and (7) Kickapoo Creek (KC) (66,689 acres).

Table 1. Acreages by Slope Classes in the Upper Embarras River Basin Subwatersheds

	Slope classes						
Subwatershed	A (0-2%)	B (2-4%)	C (4-7%)	D (7-12%)	E (12-18%)	F (18-30%)	G (over 30%)
Embarras River Direct Tributary (ERDT)	77,973	22,205	7,144	3,803	1,742	5,037	16,550
Embarras River above Camargo (ERC)	85,839	17,596	3,778	1,466	0	282	169
Scattering Fork (SF)	67,559	3,475	0	0	0	0	0
Brushy Fork (BF)	74,343	13,451	2,006	0	0	0	0
Little Embarras River (LER)	73,760	10,535	244	0	61	0	0
Polecat Creek (PC)	8,077	4,786	1,018	382	96	668	2,130
Kickapoo Creek (KC)	40,658	13,511	3,967	868	1,302	4,277	2,107
Total acreage	428,209	85,559	18,157	6,519	3,201	10,264	20,956
Percentage	74.72	14.93	3.17	1.17	0.56	1.79	3.70
				Total watershed acreage			572,865 (895.102 sq. mi.)

Because of the large size of the drainage area, which encompasses whole counties, use of soil maps and aerial photographs was not practicable. Therefore, we used data from the Conservation Needs Inventory (CNI) report [1], based on a 2-percent sample of 160-acre tracts, to project soil-type/slope/erosion-class subdivisions of the inventory acreage in the watershed area. The inventory acreage includes all land used for cropping and pasture, as well as wooded and idle land, and excludes the built-up urban area, water area, and land owned by the federal government. As far as the adequacy of CNI data for use in projecting watershed soil acreages is concerned, the study by Mausel *et al.* [6] states, "In Illinois soil maps which delineate Seventh Approximation categories can be made by using detailed 2% sample data. The accuracy and detail of these maps are good considering the limited number of soil sample areas from which they are constructed."[1]

[1] *The Seventh Approximation categories referred to by Mausel* et al. *are found in a publication by the Soil Survey Staff of the USDA's Soil Conservation Service,* Soil Classification Comprehensive System, 7th Approximation *(Washington, D.C.: U.S. Government Printing Office, 1960).*

There are 52 different soil types in this area [see Appendix 1]. They are generally dark colored. The most common soil types are Sidell, Catlin, Flanagan, and Drummer. Drummer and Flanagan soils occupy the largest part of the watershed area (55 percent of the cropland, see Appendix 3), and Catlin soil occupies the next largest part. Almost 90 percent of the area has A and B slopes. Scattering Fork, one of the subwatersheds, has no slope steeper than B as indicated by the CNI 2-percent sample [1]. After A and B, G slopes occupy the largest area. These slopes are usually covered by forests of a permanent, unimproved type. Complete information on the distribution of soil type, slope, and erosion class by subwatersheds is shown in Appendix 2. Shown in Appendix 4 is land-use acreage, based on the CNI 2-percent sample tracts in the seven subwatersheds at the time of the survey. We used this information, along with the present crop acreage statistics reported by the Crop Reporting Service [2], in determining the existing cropping pattern in order to evaluate current net incomes.

Given this information we followed these procedures:

1. Analysis of soil loss rates and net incomes above nonland cost for both a single-year and a 20-year planning period for the cropland areas of the subwatersheds under selected crop combinations.

2. Estimation of the levels of soil loss and net income under current cropping patterns for the seven subwatersheds.

3. Comparison, for one subwatershed, of the long-run annual net incomes for 50- and 100-year planning periods.

4. Estimation of sediment damage for the entire UERB and for one selected subwatershed.

5. Analysis of the combined effect of net income per acre and sediment damage in the cropland areas of UERB and in one selected subwatershed.

6. Development of the economic incentives for conservation.

NET INCOME ABOVE NONLAND COSTS AND SOIL LOSS RELATIONSHIPS

In this analysis we used the same seven crop rotations used in the previous watershed studies [4, 5, 7, 8], namely, continuous corn, C-C-Sb, C-Sb, C-C-Sb-Wx, C-Sb-C-W-M, C-W-M-M-M, and W-M-M-M. The same variations of these rotations under three tillage systems (conventional, plow-plant, and chisel-plow) and three conservation practices (up-and-down cultivation, contouring, and contouring and terracing) were considered as alternatives. The procedural steps and the assumptions about costs, prices, and management levels for computing the net incomes per acre above nonland costs for these combinations were the same as in the other reports. The following prices were used in this study: corn, $1.18 per bushel; soybeans, $2.65 per bushel; wheat, $1.34 per bushel; oats, $0.63 per bushel; and hay, $24.35 per ton. There was one major change in yield adjustment; that is, yields under the chisel-plow system are 15 percent lower for row and grain crops on soils with wetness problems and 5 percent lower on other soils than the yields under conventional tillage. Under the plow-plant system, the yields are the same as under conventional tillage.

Row crops, chiefly corn and soybeans, predominate in the region. Small grains, chiefly wheat, are of minor importance, as are meadow and pasture. This assessment is based on the CNI 2-percent sample (Appendix 4) and the actual acreages of these crops in the counties of the Upper Embarras River Watershed area (Champaign, Douglas, and Coles Counties) as shown by the crop statistics [2]. At present, the major crops in this area are corn, (approximately 50 percent) and soybeans (approximately 40 percent). Although most farmers use conventional tillage with up-and-down cultivation, conservation practices are also used to some extent. In Douglas County, conservation practices are used in about 30 percent of the cropped area [1].

Net income and soil loss per acre are shown in Tables 2 through 8. We made computations for each soil-type/slope/erosion-class acreage and averaged them for each subwatershed using area weights. Incomes were computed only for the cropland, which includes all soil types from A1 to C3. We did not estimate net income on the noncropped area, but we did estimate the soil loss.

Table 2. Net Income above Nonland Costs and Soil Loss per Acre in the Embarras River Direct Tributary Subwatershed Cropland

Crop rotation	Conventional tillage			Plow-plant tillage			Chisel-plow tillage		
	Up-and-down cultivation	Contouring	Contouring and terracing	Up-and-down cultivation	Contouring	Contouring and terracing	Up-and-down cultivation	Contouring	Contouring and terracing
Continuous corn									
Single-year net income	$78.61	$77.86	$77.60	$77.56	$76.81	$76.55	$64.87	$64.12	$63.86
20-year annualized net income	$77.91	$77.48	$77.42	$77.15	$76.60	$76.46	$64.76	$64.06	$63.83
Soil loss, tons	10.73	5.86	5.04	5.72	3.13	2.69	1.67	0.91	0.78
C-C-Sb									
Single-year net income	$76.05	$75.30	$75.04	$75.00	$74.25	$73.99	$63.50	$62.75	$62.50
20-year annualized net income	$75.40	$74.94	$74.87	$74.62	$74.05	$73.90	$63.40	$62.70	$62.47
Soil loss, tons	10.73	5.86	5.04	5.72	3.13	2.69	1.67	0.9	0.78
C-Sb									
Single-year net income	$74.77	$74.02	$73.76	$73.72	$72.97	$72.71	$62.82	$62.07	$61.82
20-year annualized net income	$73.94	$73.62	$73.57	$73.30	$72.74	$72.61	$62.70	$62.01	$61.79
Soil loss, tons	12.87	7.03	6.05	6.91	3.78	3.25	2.00	1.09	0.94
C-Sb-C-Wx									
Single-year net income	$64.70	$63.95	$63.70	$63.65	$62.90	$62.65	$53.82	$53.07	$52.81
20-year annualized net income	$64.22	$63.68	$63.57	$63.36	$62.75	$62.58	$53.74	$52.03	$52.80
Soil loss, tons	9.18	5.01	4.31	5.01	2.74	2.35	1.43	0.78	0.67
C-Sb-C-W-M									
Single-year net income	$63.01	$62.41	$62.21	$62.17	$61.57	$61.37	$54.30	$53.70	$53.50
20-year annualized net income	$62.70	$62.25	$62.13	$62.00	$61.48	$61.33	$54.22	$53.66	$53.48
Soil loss, tons	5.24	2.87	2.46	2.86	1.56	1.34	1.43	0.78	0.67
C-W-M-M-M									
Single-year net income	$53.82	$53.52	$53.42	$53.40	$53.10	$53.00	$49.89	$49.59	$49.49
20-year annualized net income	$53.74	$53.48	$53.40	$53.36	$53.08	$52.99	$49.87	$49.58	$49.48
Soil loss, tons	1.38	0.76	0.65	0.69	0.38	0.32	0.48	0.26	0.22
W-M-M-M									
Single-year net income	$48.40	$48.21	$48.15	$48.13	$47.95	$47.88	$46.92	$46.74	$46.67
20-year annualized net income	$48.37	$48.20	$48.14	$48.11	$47.94	$47.88	$46.91	$46.73	$46.67
Soil loss, tons	0.48	0.26	0.22	0.38	0.21	0.18	0.31	0.17	0.15

Table 3. Net Income above Nonland Costs and Soil Loss per Acre in the Embarras River Above Camargo Subwatershed Cropland

Crop rotation	Conventional tillage			Plow-plant tillage			Chisel-plow tillage		
	Up-and-down cultivation	Contouring	Contouring and terracing	Up-and-down cultivation	Contouring	Contouring and terracing	Up-and-down cultivation	Contouring	Contouring and terracing
Continuous corn									
Single-year net income	$88.59	$87.84	$87.69	$87.54	$86.79	$86.64	$67.40	$66.65	$66.50
20-year annualized net income	$88.30	$87.70	$87.58	$87.39	$86.72	$86.58	$67.36	$66.63	$66.49
Soil loss, tons	8.98	5.02	4.58	4.79	2.68	2.45	1.40	0.78	0.71
C-C-Sb									
Single-year net income	$85.27	$84.52	$84.37	$84.22	$83.47	$83.32	$65.90	$65.15	$65.00
20-year annualized net income	$85.00	$84.39	$84.27	$84.08	$83.40	$83.27	$65.86	$65.13	$64.99
Soil loss, tons	8.98	5.02	4.58	4.79	2.68	2.45	1.40	0.78	0.71
C-Sb									
Single-year net income	$83.60	$82.85	$82.71	$82.55	$81.80	$81.66	$65.14	$64.39	$64.25
20-year annualized net income	$83.26	$82.71	$82.60	$82.40	$81.73	$81.60	$65.10	$64.37	$64.25
Soil loss, tons	10.78	6.02	5.50	5.79	3.23	2.95	1.68	0.94	0.86
C-Sb-C-Wx									
Single-year net income	$72.46	$71.71	$71.57	$71.41	$70.66	$70.52	$55.65	$54.90	$54.76
20-year annualized net income	$72.26	$71.61	$71.49	$71.30	$70.61	$70.48	$55.63	$54.89	$54.75
Soil loss, tons	7.68	4.29	3.92	4.19	2.34	2.14	1.20	0.67	0.61
C-Sb-C-W-M									
Single-year net income	$69.96	$69.36	$69.25	$69.12	$68.52	$68.41	$56.52	$55.92	$55.80
20-year annualized net income	$69.85	$69.31	$69.21	$69.06	$68.49	$68.39	$56.49	$55.90	$55.79
Soil loss, tons	4.39	2.45	2.24	2.39	1.34	1.22	1.20	0.67	0.61
C-W-M-M-M									
Single-year net income	$58.73	$58.43	$58.37	$58.31	$58.01	$57.95	$52.67	$52.37	$52.31
20-year annualized net income	$58.70	$58.42	$58.36	$58.30	$58.00	$57.95	$52.66	$52.37	$52.31
Soil loss, tons	1.16	0.65	0.59	0.58	0.32	0.30	0.40	0.22	0.20
W-M-M-M									
Single-year net income	$52.04	$51.85	$51.82	$51.78	$51.59	$51.56	$49.76	$49.58	$49.54
20-year annualized net income	$52.03	$51.85	$51.82	$51.77	$51.59	$51.56	$49.76	$49.57	$49.54
Soil loss, tons	0.40	0.22	0.20	0.32	0.18	0.16	0.26	0.14	0.13

Table 4. Net Income above Nonland Costs and Soil Loss per Acre in the Scattering Fork Subwatershed Cropland

Crop rotation	Conventional tillage			Plow-plant tillage			Chisel-plow tillage		
	Up-and-down cultivation	Contouring	Contouring and terracing	Up-and-down cultivation	Contouring	Contouring and terracing	Up-and-down cultivation	Contouring	Contouring and terracing
Continuous corn									
Single-year net income	$85.19	$84.44	$84.44	$84.14	$83.39	$83.39	$63.21	$62.46	$62.46
20-year annualized net income	$85.13	$84.41	$84.41	$84.11	$83.38	$83.38	$63.20	$62.46	$62.46
Soil loss, tons	7.00	4.12	4.12	3.73	2.20	2.20	1.09	0.64	0.64
C-C-Sb									
Single-year net income	$83.16	$82.41	$82.41	$82.11	$81.36	$81.36	$62.89	$62.14	$62.14
20-year annualized net income	$83.11	$82.39	$82.39	$82.08	$81.35	$81.35	$62.88	$62.13	$62.13
Soil loss, tons	7.00	4.12	4.12	3.73	2.20	2.20	1.09	0.64	0.64
C-Sb									
Single-year net income	$82.15	$81.40	$81.40	$81.10	$80.35	$80.35	$62.72	$61.97	$61.97
20-year annualized net income	$82.08	$81.37	$81.37	$81.00	$80.33	$80.33	$62.72	$61.97	$61.97
Soil loss, tons	8.40	4.95	4.95	4.51	2.66	2.66	1.31	0.77	0.77
C-Sb-C-Wx									
Single-year net income	$70.66	$69.91	$69.91	$69.61	$68.86	$68.86	$53.05	$52.30	$52.30
20-year annualized net income	$70.62	$69.89	$69.89	$69.59	$68.85	$68.85	$53.04	$52.30	$52.30
Soil loss, tons	5.99	3.53	3.53	3.27	1.92	1.92	0.93	0.55	0.55
C-Sb-C-W-M									
Single-year net income	$68.29	$67.69	$67.69	$67.45	$66.85	$66.85	$54.20	$53.60	$53.60
20-year annualized net income	$68.26	$67.67	$67.67	$67.43	$66.84	$66.84	$54.19	$53.59	$53.59
Soil loss, tons	3.42	2.02	2.02	1.87	1.10	1.10	0.93	0.55	0.55
C-W-M-M-M									
Single-year net income	$57.16	$56.86	$56.86	$56.74	$56.44	$56.44	$50.84	$50.54	$50.54
20-year annualized net income	$57.15	$56.86	$56.86	$56.74	$56.44	$56.44	$50.84	$50.54	$50.54
Soil loss, tons	0.90	0.53	0.53	0.45	0.27	0.27	0.31	0.18	0.18
W-M-M-M									
Single-year net income	$50.93	$50.74	$50.74	$50.66	$50.48	$50.48	$48.52	$48.33	$48.33
20-year annualized net income	$50.92	$50.74	$50.74	$50.66	$50.48	$50.48	$48.52	$48.33	$48.33
Soil loss, tons	0.31	0.18	0.18	0.25	0.15	0.15	0.20	0.12	0.12

Table 5. Net Income above Nonland Costs and Soil Loss per Acre in the Brushy Fork Subwatershed Cropland

Crop rotation	Conventional tillage			Plow-plant tillage			Chisel-plow tillage		
	Up-and-down cultivation	Contouring	Contouring and terracing	Up-and-down cultivation	Contouring	Contouring and terracing	Up-and-down cultivation	Contouring	Contouring and terracing
Continous corn									
Single-year net income	$80.33	$79.58	$79.48	$79.28	$78.53	$78.43	$60.50	$59.75	$59.65
20-year annualized net income	$80.02	$79.41	$79.38	$79.10	$78.43	$78.37	$60.45	$59.72	$59.63
Soil loss, tons	8.46	4.77	4.52	4.51	2.55	2.41	1.32	0.74	0.70
C-C-Sb									
Single-year net income	$77.94	$77.19	$77.10	$76.89	$76.14	$76.05	$59.73	$58.98	$58.89
20-year annualized net income	$77.67	$77.04	$77.01	$76.73	$76.06	$76.00	$59.69	$58.96	$58.88
Soil loss, tons	8.46	4.77	4.52	4.51	2.55	2.41	1.32	0.74	0.70
C-Sb									
Single-year net income	$76.75	$76.00	$75.91	$75.70	$74.95	$74.86	$59.35	$58.60	$58.51
20-year annualized net income	$76.43	$75.83	$75.81	$75.52	$74.86	$74.81	$59.30	$58.57	$58.49
Soil loss, tons	10.16	5.73	5.43	5.45	3.08	2.91	1.58	0.89	0.84
C-Sb-C-Wx									
Single-year net income	$66.06	$65.31	$65.22	$65.01	$64.26	$64.17	$50.27	$49.52	$49.42
20-year annualized net income	$65.84	$65.19	$65.15	$64.88	$64.19	$64.13	$50.23	$49.50	$49.41
Soil loss, tons	7.24	4.09	3.87	3.95	2.28	2.11	1.13	0.64	0.60
C-Sb-C-W-M									
Single-year net income	$64.15	$63.55	$63.47	$63.31	$62.71	$62.63	$51.51	$50.91	$50.84
20-year annualized net income	$64.01	$63.48	$63.44	$63.23	$62.67	$62.61	$51.48	$50.90	$50.83
Soil loss, tons	4.14	2.33	2.21	2.26	1.27	1.21	1.13	0.64	0.60
C-W-M-M-M									
Single-year net income	$54.27	$53.97	$53.93	$53.85	$53.55	$52.51	$48.59	$48.29	$48.26
20-year annualized net income	$54.23	$53.95	$53.92	$53.83	$53.54	$52.50	$48.58	$48.29	$48.25
Soil loss, tons	1.09	0.62	0.58	0.55	0.31	0.29	0.38	0.21	0.20
W-M-M-M									
Single-year net income	$45.53	$48.34	$48.32	$48.26	$48.08	$48.06	$46.39	$46.20	$46.18
20-year annualized net income	$48.52	$48.33	$48.31	$48.25	$48.07	$48.05	$46.39	$46.20	$46.18
Soil loss, tons	0.38	0.21	0.20	0.30	0.17	0.16	0.24	0.14	0.13

Table 6. Net Income above Nonland Costs and Soil Loss per acre in the Little Embarras River Subwatershed Cropland

Crop rotation	Conventional tillage			Plow-plant tillage			Chisel-plow tillage		
	Up-and-down cultivation	Contouring	Contouring and terracing	Up-and-down cultivation	Contouring	Contouring and terracing	Up-and-down cultivation	Contouring	Contouring and terracing
Continuous corn									
Single-year net income	$89.05	$88.30	$88.29	$88.00	$87.25	$87.24	$67.55	$66.80	$66.79
20-year annualized net income	$88.90	$88.23	$88.22	$87.92	$87.21	$87.20	$67.53	$66.79	$66.78
Soil loss, tons	7.77	4.46	4.43	4.14	2.38	2.36	1.21	0.69	0.69
C-C-Sb									
Single-year net income	$85.92	$85.17	$85.16	$84.87	$84.12	$84.11	$66.24	$65.49	$65.47
20-year annualized net income	$85.78	$85.10	$85.09	$84.80	$84.08	$84.07	$66.22	$65.48	$65.46
Soil loss, tons	7.77	4.46	4.43	4.14	2.38	2.36	1.21	0.69	0.69
C-Sb									
Single-year net income	$84.35	$83.60	$83.59	$83.30	$82.55	$82.54	$65.58	$64.83	$64.82
20-year annualized net income	$84.20	$83.53	$83.52	$83.22	$82.51	$82.50	$65.56	$64.82	$64.81
Soil loss, tons	9.33	5.33	5.31	5.01	2.87	2.85	1.45	0.83	0.83
C-Sb-C-Wx									
Single-year net income	$73.00	$72.25	$72.24	$71.95	$71.20	$71.19	$55.93	$55.18	$55.16
20-year annualized net income	$72.90	$72.20	$72.19	$71.89	$71.17	$71.16	$55.91	$55.17	$55.16
Soil loss, tons	6.65	3.81	3.79	3.63	2.08	2.07	1.04	0.59	0.59
C-Sb-C-W-M									
Single-year net income	$70.40	$69.80	$69.79	$69.56	$68.96	$68.95	$56.75	$56.15	$56.14
20-year annualized net income	$70.35	$69.78	$69.77	$69.53	$68.95	$68.94	$56.73	$56.14	$56.13
Soil loss, tons	3.80	2.18	2.16	2.07	1.19	1.18	1.04	0.59	0.59
C-W-M-M-M									
Single-year net income	$58.89	$58.59	$58.59	$58.47	$58.17	$58.17	$52.75	$52.45	$52.44
20-year annualized income	$57.88	$58.59	$58.58	$58.47	$58.17	$58.17	$52.74	$52.44	$52.44
Soil loss, tons	1.00	0.57	0.57	0.50	0.29	0.29	0.35	0.20	0.20
W-M-M-M									
Single-year net income	$52.13	$51.94	$51.94	$51.87	$51.68	$51.68	$49.82	$49.63	$49.63
20-year annualized net income	$52.13	$51.94	$51.94	$51.87	$51.67	$51.68	$49.82	$49.63	$49.63
Soil loss, tons	0.35	0.20	0.20	0.28	0.16	0.16	0.22	0.13	0.13

Table 7. Net Income above Nonland Costs and Soil Loss per Acre in the Polecat Creek Subwatershed Cropland

Crop rotation	Conventional tillage			Plow-plant tillage			Chisel-plow tillage		
	Up-and-down cultivation	Contouring	Contouring and terracing	Up-and-down cultivation	Contouring	Contouring and terracing	Up-and-down cultivation	Contouring	Contouring and terracing
Continuous corn									
Single-year net income	$82.55	$81.80	$81.51	$81.50	$80.75	$80.46	$68.99	$68.24	$67.94
20-year annualized net income	$81.64	$81.28	$81.26	$80.95	$80.47	$80.33	$68.32	$68.16	$67.91
Soil loss, tons	11.52	6.14	5.25	6.15	3.27	2.80	1.79	0.95	0.83
C-C-Sb									
Single-year net income	$79.79	$79.04	$78.75	$78.84	$77.99	$77.70	$67.38	$66.63	$66.34
20-year annualized net income	$78.95	$78.56	$78.52	$78.23	$77.72	$77.58	$67.23	$66.56	$66.30
Soil loss, tons	11.52	6.14	5.25	6.15	3.27	2.80	1.79	0.95	0.82
C-Sb									
Single-year net income	$78.40	$77.65	$77.36	$77.35	$76.60	$76.31	$66.57	$65.82	$65.53
20-year annualized net income	$77.38	$77.11	$77.11	$76.79	$76.30	$76.18	$66.41	$65.74	$65.50
Soil loss, tons	13.83	7.37	6.30	7.43	3.96	3.38	2.15	1.15	0.98
C-Sb-C-Wx									
Single-year net income	$67.87	$67.12	$66.83	$66.82	$66.07	$65.78	$57.14	$56.39	$56.11
20-year annualized net income	$67.23	$66.75	$66.66	$66.42	$65.87	$65.69	$57.04	$56.34	$56.08
Soil loss, tons	9.86	5.25	4.49	5.38	2.86	2.45	1.54	0.82	0.70
C-Sb-C-W-M									
Single-year net income	$65.89	$65.29	$65.07	$65.05	$64.45	$64.23	$57.32	$56.72	$56.49
20-year annualized net income	$65.48	$65.08	$64.97	$64.82	$64.34	$64.17	$57.21	$56.66	$56.46
Soil loss, tons	5.63	3.00	2.57	3.07	1.64	1.40	1.54	0.82	0.70
C-W-M-M-M									
Single-year net income	$55.96	$55.66	$55.54	$55.54	$55.24	$55.12	$52.11	$51.81	$51.69
20-year annualized net income	$55.85	$55.60	$55.52	$55.48	$55.21	$55.11	$50.07	$51.79	$51.69
Soil loss, tons	1.49	0.79	0.68	0.74	0.40	0.34	0.51	0.27	0.23
W-M-M-M									
Single-year net income	$50.08	$49.89	$49.82	$49.82	$49.63	$49.56	$48.66	$48.38	$48.31
20-year annualized net income	$50.05	$49.88	$49.82	$49.79	$49.62	$49.56	$48.64	$48.37	$48.30
Soil loss, tons	0.51	0.27	0.23	0.41	0.22	0.19	0.33	0.18	0.15

Table 8. Net Income above Nonland Costs and Soil Loss per Acre in the Kickapoo Creek Subwatershed Cropland

Crop rotation	Conventional tillage			Plow-plant tillage			Chisel-plow tillage		
	Up-and-down cultivation	Contouring	Contouring and terracing	Up-and down cultivation	Contouring	Contouring and terracing	Up-and-down cultivation	Contouring	Contouring and terracing
Continuous corn									
Single-year net income	$80.66	$79.91	$79.63	$79.61	$78.86	$78.58	$62.91	$62.16	$61.88
20-year annualized net income	$80.09	$79.62	$79.46	$79.30	$78.70	$78.49	$62.83	$62.12	$61.86
Soil loss, tons	10.78	5.88	5.07	5.75	3.13	2.70	1.68	0.91	0.79
C-C-Sb									
Single-year net income	$77.68	$76.93	$76.65	$76.63	$75.88	$75.60	$61.49	$60.74	$60.47
20-year annualized net income	$77.15	$76.66	$76.50	$76.34	$75.73	$75.52	$61.41	$60.70	$60.44
Soil loss, tons	10.78	5.88	5.07	5.75	3.13	2.70	1.68	0.91	0.79
C-Sb									
Single-year net income	$76.18	$75.43	$75.16	$75.13	$74.38	$74.11	$60.78	$60.03	$59.76
20-year annualized net income	$75.49	$75.13	$74.99	$74.81	$74.22	$74.02	$60.69	$59.98	$59.73
Soil loss, tons	12.94	7.05	6.08	6.95	3.79	3.27	2.01	1.10	0.95
C-Sb-C-Wx									
Single-year net income	$66.13	$65.58	$65.11	$65.08	$64.33	$64.06	$52.08	$51.33	$51.06
20-year annualized net income	$65.75	$65.18	$65.00	$64.86	$64.22	$64.00	$52.02	$51.30	$51.04
Soil loss, tons	9.23	5.03	4.34	5.03	2.74	2.36	1.44	0.78	0.68
C-Sb-C-W-M									
Single-year net income	$64.38	$63.78	$63.57	$63.54	$62.94	$62.73	$53.14	$52.54	$52.32
20-year annualized net income	$64.15	$63.66	$63.50	$63.41	$62.88	$62.69	$53.08	$52.51	$52.31
Soil loss, tons	5.27	2.87	2.48	2.88	1.57	1.35	1.44	0.78	0.68
C-W-M-M-M									
Single-year net income	$55.08	$54.78	$54.67	$54.67	$54.37	$54.26	$50.00	$49.70	$49.59
20-year annualized net income	$55.02	$54.75	$54.65	$54.65	$54.36	$54.25	$49.98	$49.69	$49.59
Soil loss, tons	1.39	0.76	0.65	0.69	0.38	0.33	0.48	0.26	0.23
W-M-M-M									
Single-year net income	$49.46	$49.27	$49.21	$49.20	$48.81	$48.75	$47.55	$47.36	$47.29
20-year annualized net income	$49.45	$49.26	$49.20	$49.18	$48.80	$48.74	$47.53	$47.35	$47.29
Soil loss, tons	0.48	0.26	0.23	0.38	0.21	0.18	0.31	0.17	0.15

Analysis of a Single-Year Planning Period

In many respects, the results tend to follow closely those of the Mendota West Fork Watershed study [8]. Single-year incomes are the highest for continuous corn under conventional tillage and up-and-down cultivation. The highest level of income varies from $89.05 per acre on the LER subwatershed to $78.61 per acre on the ERDT subwatershed. With conventional tillage, the income level goes down as we move to the conservation practices of contouring or contouring and terracing, the latter giving the lowest income. Differences in income among subwatersheds are largely because of the distribution of soil types. For example, nearly 79 percent of the soil in the LER subwatershed (see Appendix 3) is of the highly productive Drummer and Flanagan types, whereas in the ERDT subwatershed only 37 percent is of these types. Changes in income level resulting from changes in conservation practices are proportionately similar in all the subwatersheds because cost changes among conservation practices are the same with an unaltered productivity level. The inclusion of more grain and meadow crops in the rotation leads to successive decreases in the income level because of the low profitability of crops other than corn. Thus, income per acre reaches its minimum under the W-M-M-M rotation. This minimum level varies from $48.40 per acre in the ERDT subwatershed to $52.13 per acre in the LER subwatershed. Once again, this variation in income is closely related to the distribution of soil types.

Moving to plow-plant tillage leads to small decreases in the income levels, again mainly because of cost changes. The relationships between income and conservation practice are the same as with conventional tillage. Under chisel-plow tillage, net income per acre decreases sharply. Although chisel-plowing in the prairie area has the advantages of cost savings and minimized erosion, as observed earlier, yields are decreased up to 15 percent, depending upon the wetness of the soil. Thus, with continuous corn and dominant corn rotations, income under chisel-plowing decreases about $20 per acre from income under conventional tillage. With the intensive meadow crop rotation W-M-M-M, however, this decrease is considerably less—about $3 per acre.

Corresponding to the net returns, the rainfall-induced soil losses in tons per acre were calculated. As in the case of previous watershed studies, we used the Universal Soil Loss Equation [16, 17] to compute the soil loss rates. As expected, the highly erosive row crops produce the highest soil losses. The highest level, 13.83 tons per acre, is produced by the C-Sb rotation under conventional tillage and up-and-down cultivation in the PC subwatershed. The soil loss level for C-Sb is 20 percent higher than for continuous corn or C-C-Sb. Because soybeans are a low-canopy cover crop, they are not very effective in reducing the ground impact velocity of rainfall when grown separately or rotated alternately with corn. However, when soybeans are rotated with corn once in three years (C-C-Sb), this adverse effect is modified.

The lowest level of soil loss is under chisel-plow tillage with the W-M-M-M rotation. Generally speaking, chisel-plow soil losses are well below 3 tons per acre. The soil loss rate for each crop rotation in the seven subwatersheds is shown in Tables 2 through 8. In general, the soil loss levels decrease gradually from conventional tillage with up-and-down cultivation to chisel-plow tillage with contouring and terracing.[2]

Under the cropping practices currently in use—chiefly corn and soybeans with conventional tillage and up-and-down cultivation or contouring, or both—the net income per acre ranges from approximately $75 to $82 and the soil loss runs from 4 to 7 tons per acre. In order to reduce the soil loss to a level equal to or below the tolerance level of 4 tons[3] per acre set by the Soil Conservation Service, farmers would have to accept a reduction in income. The best solution to the problem would seem to lie in changing to plow-plant tillage with contouring, a change that would result in an income reduction of only $2 per acre.

Analysis of a 20-Year Planning Period

For each crop rotation in Tables 2 through 8, the values of annualized net incomes per acre above nonland costs over a 20-year planning period for the cropland areas are also shown.

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[2]In the SF subwatershed, however, the soil loss rate is the same with contouring and terracing as with contouring because under contouring and terracing only C slopes and above are terraced, and in the SF subwatershed all soils are in A or B slopes.

[3]The tolerance level is taken as 4 tons per acre as suggested by the Soil Conservation Service for most soils.

In computing these values, we took into account the impact of annual loss of topsoil on productivity. Thus, we generated and annualized a 20-year series of net incomes, using the capital budgeting procedure we used in the other watershed studies.

In general, the annualized net incomes for the 20-year planning period are lower than those for the single-year period. This drop in income ranges from no change to a change of $1, depending on the soil loss levels for each crop rotation, tillage system, and conservation practice. We observed earlier that the continuous corn and C-Sb rotations under conventional tillage produce the highest soil loss rates. Therefore, the drop in income is the greatest for these rotations. There are also differences among subwatersheds in the decrease in income per acre. These differences are largely because of variations in the soil loss rate. Crop rotations with intensive meadow produce minimum soil losses and, therefore, do not show any marked drop in income levels over the 20-year planning period. The situation is similar with chisel-plow tillage. Obviously, most of the noticeable drops in income accompany crop rotations involving row crops or a combination of row and grain crops (continuous corn to C-Sb-C-W-M) under conventional and plow-plant tillage. However, when compared with the figures in the studies of southern and western Illinois watersheds (Crab Orchard [7], Sevenmile Creek [5], and Hambaugh-Martin [4]), decreases in income under the 20-year planning period in the UERB appear to be very small. The difference is chiefly that the watersheds in the central Illinois prairie are relatively flat and suffer little from slight erosion. We also noticed that the order of crop alternatives—ranked from the highest to the lowest net income per acre—under the 20-year planning period remains the same as under the single-year period.

When we made a cursory examination of the 20-year net incomes by grouping the subwatershed crop areas according to slopes (A, B, and C), we found that with intensive row crop rotations (continuous corn to C-Sb-C-W-M) there is a decrease in net income per acre of about 30 to 35 percent (or $25 to $30) between slopes A and C for similar tillage and conservation practices. This difference is narrowed to 3 percent (or $2 to $3 per acre) between slopes A and B. With intensive meadow rotations, the difference between slopes A and C is 15 to 20 percent, and between slopes A and B it is 1 to 2 percent ($1 to $2 per acre).

Analysis of 50- and 100-Year Planning Periods

In a relatively flat watershed, an increase in the planning period to 100 years would be likely to change the income ranking of crop rotation and tillage practice alternatives. For example, although continuous corn with up-and-down cultivation in the PC subwatershed gives the highest net income per acre under the single-year and 20-year planning periods, it may not remain in that position under an extended planning period of 50 or 100 years because of the high annual erosion rate of 11.52 tons.

Table 9, which gives the annualized net income per acre for planning periods of 50 and 100 years for the PC subwatershed, illustrates this point. The UERB, located in the fertile prairie area, is characterized in general by flat topography and a low erosion rate. But the cropland in the PC subwatershed has more area in the range of slopes A to C and also has erosion class variations and, therefore, a higher soil loss level. Consequently, this subwatershed was chosen to illustrate the effect of long-run soil erosion on productivity. In Table 9, under each crop rotation alternative, we also show the estimated per acre net income for single-, 20-, 50-, and 100-year planning periods. For the 50- and 100-year analysis, we used the same procedure as for the 20-year period. The following points are worth noting:

1. As we increase the planning period from one year to 100 years, the difference in annualized income levels among conservation practices under each tillage system decreases. Similar decreases in the differences in income level among tillage systems are also observed.

2. These income differences among tillage systems are all small, but they are the greatest for the intensive row crop rotations and almost insignificant for heavy meadow rotations (C-W-M-M-M and W-M-M-M).

3. In general, the impact of long-run soil erosion on productivity and income, measured in the decrease in dollars of income from the single-year levels, is very small for intensive row crop rotations under conventional and plow-plant tillage. It is

3. smaller for row crop and meadow sequences. Under chisel-plow tillage and with heavy meadow crop rotations, the impact is practically negligible.

4. For the row crop rotations (continuous corn, C-C-Sb, and C-Sb) under conventional tillage, income is highest under contouring and terracing for the 50- and 100-year planning periods, whereas for the single-year and 20-year planning periods, income is highest under up-and-down cultivation.

Income changes are expected to be smaller in other subwatersheds because their soil loss rates are lower than those of the PC subwatershed. On the whole, in the UERB, the impact of soil erosion on productivity appears to be minor. Therefore, to compare the effectiveness of the alternative crop systems, it is important to evaluate the impact of soil erosion on nonagricultural and off-farm activities, in terms of sediment damages.

Analysis of Net Land Rent Effects

We have referred in our earlier studies [4, 5, 7] to the long-term effects of soil loss on land rent as yet another consequence of erosion. The current productivity index values for soils in the UERB are in the range of 75 to 100 [10, P.11]. When we take into account the long-term effect of soil loss, using the same procedure as in the other studies, the index values undergo only a slight change. We also find from Reiss's study [11] that there is practically no variation in net land rent for the tenant-operated farms in central Illinois in the productivity index range of 70 to 100. We may conclude, therefore, that the long-term effects of soil loss on net land rent are of little consequence in the UERB and its subwatersheds.

SOIL LOSS AND SEDIMENT DAMAGE RELATIONSHIPS

Having calculated the gross erosion rates of each subwatershed for selected cropping management alternatives, we estimated the sediment damage in order to evaluate alternative methods of controlling soil loss.

Estimation Methods

In this study, the methods used to estimate sediment damage were slightly different because the watershed is larger than those in previous studies and data such as those found in work plans developed for P.L. 566 watersheds were unavailable.

We calculated separately the damage in the upstream part of the watershed and that in the downstream part. The upstream damage consists of two major items—the cost of maintaining the drainage ditch and the flood-associated sediment damage. The drainage ditch maintenance cost is defined as the deposited sediment times the unit cost of dredging, which the Soil Conservation Service estimates at $0.50 per ton [14]. The amount of sediment deposited in the drainage ditch is assumed to be the gross erosion less the sediment yield at the watershed outlet, multiplied by a constant fraction because not all the sediment in the watershed is deposited in the drainage ditch—only about half, according to the SCS [14].

The flood-associated sediment damage is based on reduction in yield. The inventory of conservation needs [1] provides the data for calculating the acreages subject to flooding in each subwatershed. We assumed the reduction in yield due to flooding in each subwatershed to be 20 percent [14] of the gross value of the crop (net income per acre [Tables 2 through 8] plus planting cost times the number of acres subject to flooding). Only a small part of flood damage, however, is due to sediment deposition—about 10 percent, according to the study of the Upper Mississippi Basin [12]. For this study, we used 10 percent as the part of flood damage caused by sediment deposition associated with conventional tillage and up-and-down cultivation of continuous corn, and we assumed that the damage with the other conservation management alternatives is proportional to their gross erosion rates.

We calculated the downstream damage by means of the sediment damage function developed in the previous watershed studies [4, 5, 7], assuming the presence of a reservoir. The total. gross erosion in the downstream area was assumed to be the sum of the gross erosion in the downstream area itself and the sediment yield from upstream.

Table 9. Comparison of Single-Year Net Income per Acre above Nonland Costs with Annualized Net Income under 20-, 50-, and 100-Year Planning Periods in the Polecat Creek Subwatershed

Crop rotation	Conventional tillage			Plow-plant tillage			Chisel-plow tillage		
	Up-and-down cultivation	Contouring	Contouring and terracing	Up-and-down cultivation	Contouring	Contouring and terracing	Up-and-down cultivation	Contouring	Contouring and terracing
Continuous corn									
Single-year net income	$82.55	$81.80	$81.51	$81.50	$80.75	$80.46	$68.99	$68.24	$67.94
20-year annualized net income	81.64	81.28	81.26	80.95	80.47	80.33	68.83	68.16	67.91
50-year annualized net income	80.96	81.01	81.10	80.66	80.30	80.24	68.73	68.11	67.88
100-year annualized net income	80.82	80.92	81.05	80.56	80.26	80.22	68.71	68.09	67.88
C-C-Sb									
Single-year net income	$79.79	$79.04	$78.75	$78.84	$77.99	$77.70	$67.38	$66.63	$66.34
20-year annualized net income	78.95	78.56	78.52	78.23	77.72	77.58	67.23	66.56	66.30
50-year annualized net income	78.32	78.31	78.37	77.96	77.57	77.50	67.14	66.51	66.28
100-year annualized net income	78.19	78.22	78.33	77.87	77.53	77.47	67.12	66.49	66.27
C-Sb									
Single-year net income	$78.40	$77.65	$77.36	$77.35	$76.60	$76.31	$66.57	$65.82	$65.53
20-year annualized net income	77.38	77.11	77.11	76.79	76.30	76.18	66.41	65.74	65.50
50-year annualized net income	76.72	76.80	76.94	76.44	76.14	76.08	66.30	65.68	65.67
100-year annualized net income	76.55	76.71	76.89	76.35	76.09	76.06	66.27	65.67	65.46
C-Sb-C-Wx									
Single-year net income	$67.87	$67.12	$66.83	$66.82	$66.07	$65.78	$57.14	$56.39	$56.11
20-year annualized net income	67.23	66.75	66.66	66.42	65.87	65.69	57.04	56.34	56.08
50-year annualized net income	66.75	66.57	66.55	66.22	65.74	65.63	56.96	56.30	56.07
100-year annualized net income	66.66	66.50	66.52	66.15	65.71	65.61	56.94	56.29	56.06
C-Sb-C-W-M									
Single-year net income	$65.89	$65.29	$65.07	$65.05	$64.45	$64.23	$57.23	$56.72	$56.49
20-year annualized net income	65.48	65.08	64.97	64.82	64.34	64.77	57.21	56.66	56.46
50-year annualized net income	65.26	64.96	64.90	64.68	64.26	64.14	57.13	56.62	56.44
100-year annualized net income	65.19	64.92	64.89	64.65	64.24	64.13	57.11	56.61	56.44
C-W-M-M-M									
Single-year net income	$55.96	$55.66	$55.54	$55.54	$55.24	$55.12	$52.11	$51.81	$51.69
20-year annualized net income	55.85	55.60	55.52	55.48	55.21	55.11	52.07	51.79	51.69
50-year annualized net income	55.77	55.56	55.50	55.44	55.19	55.10	52.05	51.78	51.68
100-year annualized net income	55.75	55.55	55.49	55.43	55.18	55.10	52.04	51.77	51.68
W-M-M-M									
Single-year net income	$50.08	$49.89	$49.82	$49.82	$49.63	$49.56	$48.66	$48.48	$48.41
20-year annualized net income	50.05	49.88	49.82	49.79	49.62	49.56	48.64	48.47	48.40
50-year annualized net income	50.02	49.86	49.81	49.77	49.61	49.55	48.63	48.46	48.40
100-year annualized net income	50.01	49.86	49.81	49.77	49.60	49.55	48.62	48.46	48.40

Data

We collected the following data in order to assess off-site sediment damages:

1. Size of drainage areas of the basin and subwatersheds, measured from maps (Table 10, row 1).

2. Number of acres, both agricultural and urban, subject to flood and sediment damage [1] (Table 10, row 2).

3. Cost of reservoir installation or channel improvement. The cost of the proposed Lincoln reservoir was estimated by the U.S. Army Corps of Engineers [13] on the basis of 1971 prices (Table 10, row 3). The cost of the P.L. 566 channel improvement project, currently under construction in the SF subwatershed [15], was estimated on the basis of 1969 prices (Table 10, row 3).

4. Land use, based on the 2-percent sample CNI tracts [1] (Table 10, rows 4 to 9).

5. Annual downstream flood and sediment damage. Flood damage to the downstream acre of the UERB was reported for two situations [12], estimated on the basis of 1971 prices—$7,487,000 under present conditions and $5,668,000 if a proposed reservoir is built.

6. Allocation of reservoir space [12]—sediment pool capacity, 63,100 acre-feet; water supply and recreation, 19,250 acre-feet; and flood control storage capacity, 48,701 acre-feet.

Table 10. Input Data Used in Estimating Sediment Damage in the Upper Embarras River Basin

	Subwatersheds						
	Embarras River Direct Tributary	Embarras River above Camargo	Scattering Fork	Polecat Creek	Little Embarras River	Brushy Creek	Kickapoo Creek
Subwatershed drainage area (square miles)	210	171	111	268	132	140	104
Number of acres having flood and sediment problems[a]							
Agricultural	10,000	8,323	3.050	250	320	4,400	5,710
Urban	0	95	72	0	0	20	0
Project cost at the area	$63,340,000	---[b]	$1,553,000	---	---	---	---
Land use (acres)[a]							
Row crops	67,282	78,734	53,314	9,381	71,996	58,997	35,329
Small grain	14,340	10,716	17,099	2,321	5,908	22,058	6,570
Pasture	19,121	16,976	208	3,212	5,482	11,203	15,123
Woodland	29,606	1,636	0	3,085	0	0	558
Other	4,420	3,666	417	445	1,218	2,642	3,657
Delivery ratio[c]	0.075	0.080	0.094	0.140	0.170	0.165	0.180

[a]From the CNI report [1].
[b]No project.
[c]Adapted from the SCS delivery ratio curve [9].

7. Sediment-delivery ratio. Sediment transport from agricultural land is a complex process. One commonly used method of estimating the sediment yield is to utilize the reservoir survey data in the adjacent area. Two surveys of reservoir-trapped sediment have been reported near the UERB area [3, 12]: (a) Lake Springfield, with a watershed area of 265 square miles, had a reservoir capacity loss of 2,659 acre-feet from 1934 to 1948. In other words, the watershed deposited about 0.69 acre-foot of sediment per square mile per year in the reservoir. If one acre-foot of sediment is assumed to be 1,300 tons, sediment deposition is about 1.40 tons per acre per year. Of course, this is an average taken over a 14-year period, many years ago. It is conceivable that more intensive land cultivation in the watershed in recent years has increased the potential sediment yield. (b) Lake Charleston, with a drainage area of 785 square miles, has lost 40 percent of its original capacity, or 0.09 acre-foot per square mile per year. For comparison with Lake Springfield, however, the watershed characteristics and land use would have to be identified. It was observed by the U.S. Army Corps of Engineers [12] that because of the configuration of the Lake Charleston watershed, about three-fourths of the gross erosion is deposited in the stream system and about one-fourth in the reservoir. Quantitative data are not yet available. We decided to use the SCS delivery ratio curve [9] to calculate the sediment yield because it is more flexible in handling different land management alternatives. This family of curves defines the delivery ratio as a function of the drainage area, with the sediment particle size as the parameter (Table 10, row 10).

Results

Using the estimation methods and data referred to in the previous sections, we calculated the upstream off-site sediment damage and the downstream off-site sediment damage. Sediment damage estimates for each cropping alternative in the Embarras River direct drainage area and the six subwatersheds are given in Table 11. Some interesting features are apparent: (a) In the upstream subwatersheds, the cost of maintaining the drainage ditch is much higher than the flood-associated sediment damage because a comparatively smaller area is inundated and a large amount of sediment is deposited in the drainage ditch near the sediment source. (b) In this particular river basin, since there is a relatively large sediment pool, the reservoir-related sediment damage (which includes (1) the annual increase in reservoir cost, (2) the increase in flood damage after the end of the reservoir life, and (3) the loss of incidental recreational benefits) is not a significant part. However, the water supply would be affected by the turbidity in the reservoir caused by the high gross erosion and sediment yield. The result would be an increase in the cost of the water supply operation, a factor which is not included in this study. (c) The gross erosion rate, the number of acres subject to flood and sediment damage, and the gross value of crops play important roles in determining sediment damage. Estimation of downstream sediment damage, however, is based on the assumption that, for a given estimate, the "same" rotation is used in all the subwatersheds, an assumption that might not correspond to the facts. However, since a range of rotations is used, the results are likely to include the actual situation.

COMBINING NET FARM INCOME AND COST OF SEDIMENT DAMAGE

As in the other watershed studies [4, 5, 7, 8], we assessed the consequences of controlling soil erosion on agricultural land by calculating net social income—net farm income (above nonland costs) minus the cost of sediment damage. The UERB is a very large river basin, or watershed, containing seven fairly large subwatersheds. Earlier, we estimated two categories of damage—the damage cost to each upstream subwatershed and flood-associated sediment damage to the downstream reservoir caused by sedimentation from the entire basin. In the same way, we present here a twofold estimate of net social income, one for the whole river basin as a watershed unit and the other for each individual subwatershed.

1. First we considered the whole Upper Embarras River Basin as one watershed unit. We averaged the current net incomes per acre of the seven subwatersheds (see Tables 2 through 8), using area weights, to arrive at an average net income per acre of cropland for each combination of rotation, tillage, and conservation practice. We also summed all the damage costs for the seven subwatersheds for all combinations of crop rotation, tillage, and conservation practice (see Table 11). We added to this figure the aggregated costs of damage to the downstream reservoir to get the total cost of damage. Since this total includes the cost of damages from noncropland sedimentation, we allocated the total cost between cropland and noncropland,

Table 11. Off-Site Sediment Damage in the Upper Embarras River Basin Subwatersheds

(In thousands of dollars)

On-site conservation alternatives[a] with different crop rotations	Subwatersheds														Downstream flood-associated sediment damage with reservoir[b]
	Embarras River Direct Tributary		Embarras River above Camargo		Scattering Fork		Polecat Creek		Little Embarras River		Brushy Fork		Kickapoo Creek		
	FA[c]	DD[c]	FA	DD	FA	DD	FA	DD	FA	DD	FA	DD	FA	DD	
Continuous corn															
CV, U/D	23.0	324	2.0	224	0.5	113	1.4	159	0	142	0	40	1.5	144	566
CV, CT	13.0	193	1.0	125	0.2	66	0.7	90	0	81	0	25	0.9	86	336
CV, CT/T	11.0	171	1.0	114	0.2	66	0.6	85	0	81	0	22	0.8	76	302
PP, U/D	12.0	189	1.0	119	0.2	60	0.6	85	0	76	0	25	0.8	84	327
PP, CT	7.0	119	0.5	67	0.0	35	0.3	48	0	44	0	16	0.4	53	204
PP, CT/T	6.0	107	0.5	61	0.0	35	0.3	45	0	43	0	15	0.3	48	186
CP, U/D	4.0	81	0.4	35	0.0	17	0.0	25	0	22	0	12	0.1	35	134
CP, CT	2.0	59	0.2	19	0.0	10	0.0	14	0	13	0	10	0.0	26	97
CP, CT/T	2.0	56	0.2	18	0.0	10	0.0	13	0	13	0	9	0.0	25	92
C-C-Sb															
CV, U/D	22.0	323	1.3	223	0.3	113	1.0	159	0	141	0	40	1.2	145	567
CV, CT	12.0	192	0.6	124	0.1	66	0.5	90	0	81	0	25	0.6	86	335
CV, CT/T	11.0	170	0.5	113	0.1	66	0.5	85	0	81	0	22	0.5	76	302
PP, U/D	12.0	188	0.5	119	0.1	60	0.5	85	0	75	0	24	0.6	84	327
PP, CT	6.0	119	0.3	66	0.0	35	0.2	48	0	44	0	16	0.3	53	204
PP, CT/T	5.0	107	0.2	61	0.0	35	0.2	45	0	43	0	15	0.2	47	186
CP, U/D	4.0	81	0.3	35	0.0	17	0.2	25	0	22	0	12	0.0	35	134
CP, CT	2.0	59	0.2	19	0.0	10	0.1	14	0	13	0	10	0.0	26	97
CP, CT/T	2.0	56	0.1	18	0.0	10	0.1	13	0	13	0	9	0.0	25	92
C-Sb															
CV, U/D	27.0	381	1.0	267	0.2	135	1.0	191	0	169	0	46	1.1	170	669
CV, CT	15.0	231	0.5	149	0.0	79	0.5	108	0	97	0	28	0.6	99	401
CV, CT/T	12.0	197	0.4	136	0.0	79	0.5	102	0	97	0	25	0.5	88	352
PP, U/D	14.0	220	0.4	143	0.0	72	0.5	102	0	91	0	28	0.5	98	384
PP, CT	8.0	136	0.2	79	0.0	43	0.2	58	0	53	0	18	0.3	60	236
PP, CT/T	7.0	122	0.1	73	0.0	43	0.2	55	0	52	0	17	0.2	54	236
CP, U/D	5.0	89	0.3	42	0.0	21	0.3	30	0	27	0	13	0.3	39	214
CP, CT	3.0	64	0.2	23	0.0	12	0.1	17	0	15	0	10	0.2	28	149
CP, CT/T	2.0	60	0.1	21	0.0	12	0.1	16	0	15	0	10	0.2	27	106

See footnotes on page 19.

Table 11. (continued)

On-site conservation alternatives[a] with different crop rotations	Subwatersheds														Downstream flood-associated sediment damage with reservoir[b]
	Embarras River Direct Tributary		Embarras River above Camargo		Scattering Fork		Polecat Creek		Little Embarras River		Brushy Fork		Kickapoo Creek		
	FA[c]	DD[c]	FA	DD	FA	DD	FA	DD	FA	DD	FA	DD	FA	DD	
C-Sb-C-Wx															
CV, U/D	16.0	279	0.5	189	0.5	96	0.7	136	0	121	0	35	0.8	126	493
CV, CT	9.0	168	0.2	106	0.5	57	0.3	77	0	69	0	22	0.4	76	295
CV, CT/T	8.0	149	0.2	97	0.5	57	0.3	73	0	69	0	20	0.3	67	266
PP, U/D	9.0	168	0.2	103	0.4	53	0.3	74	0	66	0	22	0.4	75	293
PP, CT	5.0	107	0.1	58	0.2	31	0.1	42	0	38	0	15	0.2	48	185
PP, CT/T	4.0	97	0.0	53	0.2	31	0.1	39	0	38	0	14	0.2	43	169
CP, U/D	3.0	73	0.3	30	0.0	15	0.2	21	0	19	0	11	0.0	32	122
CP, CT	2.0	55	0.1	17	0.0	9	0.1	12	0	11	0	9	0.0	24	91
CP, CT/T	1.0	53	0.1	15	0.0	9	0.1	11	0	11	0	9	0.0	23	86
C-Sb-C-W-M															
CV, U/D	9.0	174	0.3	118	0.4	55	0.2	78	0	69	0	23	0.3	78	304
CV, CT	5.0	111	0.1	70	0.2	33	0.1	44	0	40	0	15	0.2	49	192
CV, CT/T	4.0	100	0.1	65	0.2	33	0.1	41	0	39	0	14	0.1	45	175
PP, U/D	5.0	109	0.1	67	0.2	30	0.1	42	0	38	0	16	0.2	49	188
PP, CT	3.0	76	0.0	41	0.1	18	0.0	24	0	22	0	12	0.0	34	128
PP, CT/T	2.0	70	0.0	38	0.1	18	0.0	23	0	22	0	11	0.0	31	119
CP, U/D	3.0	73	0.1	30	0.0	15	0.0	21	0	19	0	11	0.0	32	122
CP, CT	2.0	55	0.0	17	0.0	9	0.0	12	0	11	0	9	0.0	24	91
CP, CT/T	1.0	53	0.0	15	0.0	9	0.0	11	0	11	0	9	0.0	23	86
C-W-M-M-M															
CV, U/D	2.0	71	0.3	29	0.0	15	0.0	20	0	18	0	11	0.1	32	119
CV, CT	1.0	55	0.2	16	0.0	8	0.0	12	0	11	0	9	0.0	24	90
CV, CT/T	1.0	52	0.1	15	0.0	8	0.0	11	0	11	0	9	0.0	23	85
PP, U/D	1.0	53	0.1	14	0.0	7	0.0	10	0	9	0	9	0.0	23	86
PP, CT	0.6	45	0.1	8	0.0	4	0.0	6	0	5	0	8	0.0	20	71
PP, CT/T	0.5	43	0.0	7	0.0	4	0.0	5	0	5	0	8	0.0	19	69
CP, U/D	0.8	46	0.0	10	0.0	5	0.0	7	0	7	0	8	0.0	21	74
CP, CT	0.5	42	0.0	5	0.0	3	0.0	4	0	4	0	7	0.0	18	66
CP, CT/T	0.4	40	0.0	10	0.0	3	0.0	4	0	4	0	7	0.0	18	64

See footnotes on page 19.

Table 11. (continued)

On-site conservation alternatives[a] with different crop rotations	Subwatersheds														Downstream flood-associated sediment damage with reservoir[b]
	Embarras River Direct Tributary		Embarras River above Camargo		Scattering Fork		Polecat Creek		Little Embarras River		Brushy Fork		Kickapoo Creek		
W-M-M-M	FA[c]	DD[c]	FA	DD	FA	DD	FA	DD	FA	DD	FA	DD	FA	DD	
CV, U/D	0.6	47	0.0	10	0.0	5	0.0	7	0	7	0	9	0.0	21	76
CV, CT	0.4	41	0.0	6	0.0	3	0.0	4	0	4	0	8	0.0	18	66
CV, CT/T	0.3	40	0.0	5	0.0	3	0.0	4	0	4	0	8	0.0	18	64
PP, U/D	0.5	45	0.0	8	0.0	4	0.0	6	0	5	0	8	0.0	20	71
PP, CT	0.3	40	0.0	5	0.0	2	0.0	3	0	3	0	8	0.0	18	63
PP, CT/T	0.2	39	0.0	4	0.0	2	0.0	3	0	3	0	8	0.0	17	62
CP, U/D	0.5	43	0.0	6	0.0	3	0.0	5	0	4	0	8	0.0	18	68
CP, CT	0.3	39	0.0	3	0.0	2	0.0	3	0	2	0	7	0.0	17	61
CP, CT/T	0.3	38	0.0	3	0.0	2	0.0	2	0	2	0	7	0.0	17	60

[a]CV = conventional tillage, PP = plow-plant tillage, CP = chisel-plow tillage, UD = up-and-down cultivation, CT = contouring, and CT/T = contouring and terracing.

[b]Based on the proposed reservoir capacity of 131,051 acre-feet, which includes (1) 63,100 acre-feet for sediment storage capacity, (2) 19,250 acre-feet for water supply and recreation uses, and (3) 48,701 acre-feet for flood-control purposes.

[c]FA = flood-associated sediment damage, DD = drainage ditch sediment damage.

using their sediment load[d] proportions as the basis. Then we divided the total damage cost for the cropland for each crop rotation alternative by the cropland area to arrive at the damage cost per acre. We then computed the net social income per acre (Table 12). We assumed that any crop combination specified as an alternative would be planted over the entire crop area of the basin (in all the subwatersheds).

Table 12. Net Income and Sediment Damage per Acre per Year in the Upper Embarras River Basin Cropland

Crop rotation	Tillage system[a]	Conservation practice[b]	Net income[c]	Sediment damage[d]	Net social income[e]	Sediment damage expressed as a percentage of net income
	(1)	(2)	(3)	(4)	(5)	(6)
Continuous corn	Con	UD	$83.77	$3.04	$80.73	3.6
		CT	83.03	1.69	81.34	2.0
		CT/T	82.88	1.54	81.34	1.9
	PP	UD	82.70	1.63	81.07	2.0
		CT	81.98	0.90	81.08	1.1
		CT/T	81.84	0.82	81.02	1.0
	CP	UD	64.74	0.47	64.27	0.7
		CT	63.99	0.26	63.72	0.4
		CT/T	63.84	0.24	63.61	0.4
C-C-Sb	Con	UD	81.02	2.82	78.20	3.5
		CT	80.27	1.69	78.58	2.1
		CT/T	80.13	1.54	78.59	1.9
	PP	UD	79.97	1.63	78.34	2.0
		CT	79.22	0.90	78.32	1.1
		CT/T	79.06	0.82	78.24	1.0
	CP	UD	63.58	0.47	63.11	0.7
		CT	62.83	0.26	62.57	0.4
		CT/T	62.69	0.24	62.45	0.4
C-Sb	Con	UD	79.64	3.64	76.00	4.6
		CT	79.26	2.04	77.22	2.6
		CT/T	78.76	1.84	76.92	2.3
	PP	UD	78.59	1.93	76.66	2.6
		CT	77.86	1.07	76.79	1.4
		CT/T	77.72	0.99	76.73	1.3
	CP	UD	62.70	0.63	62.07	1.0
		CT	62.25	0.34	61.91	0.5
		CT/T	62.11	0.28	61.83	0.5
C-Sb-C-Wx	Con	UD	68.86	2.28	66.58	3.3
		CT	68.11	1.44	66.67	2.1
		CT/T	67.96	1.31	66.65	1.9
	PP	UD	67.80	1.42	66.38	2.1
		CT	67.04	0.78	66.26	1.2
		CT/T	66.91	0.70	66.21	1.0
	CP	UD	53.72	0.40	53.32	0.7
		CT	52.96	0.22	52.74	0.4
		CT/T	52.83	0.20	52.63	0.4
C-Sb-C-W-M	Con	UD	66.71	1.49	65.22	2.2
		CT	66.11	0.83	65.28	1.3
		CT/T	66.00	0.76	65.24	1.3
	PP	UD	65.87	0.80	65.07	1.2

See table footnotes on next page.

[d] *The sediment load from cropland and noncropland areas for each subwatershed is obtained by multiplying the soil-loss load by the respective sediment-delivery ratios given in Table 10.*

Table 12. (continued)

Crop rotation	Tillage system[a]	Conservation practice[b]	Net income[c]	Sediment damage[d]	Net social income[e]	Sediment damage expressed as a percentage of net income
	(1)	(2)	(3)	(4)	(5)	(6)
		CT	$65.27	$0.46	$64.81	0.7
		CT/T	65.16	0.42	64.74	0.6
	CP	UD	54.60	0.40	54.20	0.7
		CT	54.00	0.22	53.78	0.4
		CT/T	53.90	0.20	53.70	0.4
C-W-M-M-M	Con	UD	56.33	0.38	55.95	0.7
		CT	56.03	0.22	55.81	0.4
		CT/T	55.98	0.19	55.79	0.3
	PP	UD	55.91	0.19	55.72	0.3
		CT	55.61	0.10	55.51	0.2
		CT/T	55.39	0.09	55.30	0.2
	CP	UD	48.19	0.13	48.06	0.3
		CT	47.89	0.08	47.81	0.2
		CT/T	47.69	0.07	47.62	0.1
W-M-M-M	Con	UD	50.25	0.13	50.12	0.3
		CT	50.05	0.07	49.98	0.1
		CT/T	50.00	0.06	49.94	0.1
	PP	UD	49.96	0.11	49.85	0.2
		CT	49.77	0.06	49.71	0.1
		CT/T	49.72	0.05	49.67	0.1
	CP	UD	48.19	0.09	48.10	0.2
		CT	47.84	0.04	47.80	0.1
		CT/T	47.80	0.03	47.77	0.1

[a]Con = conventional tillage, PP = plow-plant tillage, and CP = chisel-plow tillage.
[b]UD = up-and-down cultivation, CT = contouring, and CT/T = contouring and terracing.
[c]Net of nonland costs, weighted average for the cropland.
[d]As computed by using the procedures discussed in the text.
[e]Column 3 minus column 4.

2. Next we considered net social income for the individual subwatersheds. This information might be helpful in an analysis of the economics of erosion and sedimentation in a subwatershed management program. We first obtained from Tables 2 through 8 the net incomes per acre for the subwatershed in question for each crop rotation alternative. Then we aggregated the damage costs within the subwatershed as shown in Table 11 and determined the portion attributable to cropland only, on the basis of the cropland sediment load. We divided this figure by the cropland area to obtain the cost per acre of damage within the subwatershed in question and added to this the cost per acre of damage to the downstream reservoir, which was computed by dividing the cropland portion of the downstream flood-associated sediment damage with reservoir (Table 11) under each crop combination for the whole basin by the cropland area in the basin. The major assumption here is that whenever a particular crop rotation alternative for any subwatershed is considered, the crop rotation alternative practiced in the remaining subwatersheds is the same.

   As an example, the net social incomes for the PC subwatershed are shown in Table 13. The PC subwatershed represents the upper limit in terms of damage costs per acre. It has the smallest drainage and cropland area and has noncropland in D, E, F, and G slopes.

Table 12, which gives the results for the whole basin, shows that the damage costs are highest for intensive row crop rotations with conventional tillage and up-and-down cultivation. The C-Sb rotation shows a damage rate of $3.04 per acre under conventional tillage with up-and-down cultivation. As we move to contouring or contouring and terracing, the damage

rate decreases substantially. Using plow-plant tillage further reduces the damage rate, and minimum damage occurs under chisel-plow tillage. With the C-W-M-M-M and W-M-M-M rotations, the damage levels are less than $0.50 per acre. Once again, we note appreciable reduction in sediment damage with plow-plant and chisel-plow tillage under contouring or contouring and terracing.

Table 13. Net Income and Sediment Damage per Acre per Year in the Polecat Creek Subwatershed Cropland

Crop rotation	Tillage system[a]	Conservation practice[b]	Net income[c]	Sediment damage[d]	Net social income[e]	Sediment damage expressed as a percentage of net income
	(1)	(2)	(3)	(4)	(5)	(6)
Continuous corn	Con	UD	$82.55	$10.20	$72.35	12.4
		CT	81.80	4.96	76.84	6.1
		CT/T	81.51	4.50	77.01	5.5
	PP	UD	81.50	3.84	77.66	4.7
		CT	80.75	2.31	78.44	2.9
		CT/T	80.46	1.88	78.58	2.3
	CP	UD	68.99	0.77	68.22	1.1
		CT	68.24	0.30	67.94	0.4
		CT/T	67.94	0.29	67.65	0.4
C-C-Sb	Con	UD	79.79	10.20	69.59	12.8
		CT	79.04	4.96	74.08	6.3
		CT/T	78.75	4.50	74.25	5.7
	PP	UD	78.75	3.84	74.91	4.9
		CT	78.74	2.31	76.43	2.9
		CT/T	77.99	1.88	76.11	2.4
	CP	UD	67.70	0.77	66.93	1.1
		CT	67.38	0.30	67.08	0.4
		CT/T	66.63	0.29	66.33	0.4
C-Sb	Con	UD	78.40	12.68	65.72	16.1
		CT	77.65	6.28	71.37	8.1
		CT/T	77.36	5.70	71.66	7.3
	PP	UD	77.35	5.94	71.41	7.7
		CT	76.60	2.76	73.84	3.6
		CT/T	76.31	2.56	73.75	3.4
	CP	UD	66.57	1.28	65.29	1.9
		CT	65.82	0.56	65.26	0.9
		CT/T	65.53	0.31	65.22	0.5
C-Sb-C-Wx	Con	UD	67.87	8.55	59.32	12.6
		CT	67.12	4.08	63.04	6.1
		CT/T	66.83	3.63	63.20	5.4
	PP	UD	66.82	3.88	62.94	5.8
		CT	66.07	1.77	64.30	2.7
		CT/T	65.78	1.44	64.34	2.2
	CP	UD	57.14	0.65	56.49	1.1
		CT	56.39	0.31	56.08	0.5
		CT/T	56.11	0.28	55.83	0.5
C-Sb-C-W-M	Con	UD	65.89	4.20	61.69	6.4
		CT	65.29	1.89	63.40	2.9
		CT/T	65.07	1.76	63.31	2.7
	PP	UD	65.05	1.98	63.07	3.0
		CT	64.45	0.76	63.69	1.2
		CT/T	64.23	0.65	63.58	1.0
	CP	UD	57.32	0.65	56.67	1.1
		CT	56.72	0.32	56.40	0.6

See footnotes on next page.

Table 13. (continued)

Crop rotation	Tillage system[a]	Conservation practice[b]	Net income[c]	Sediment damage[d]	Net social income[e]	Sediment damage expressed as a percentage of net income
	(1)	(2)	(3)	(4)	(5)	(6)
		CT/T	$56.49	$ 0.28	$56.21	0.5
C-W-M-M-M	Con	UD	54.58	0.62	53.96	1.1
		CT	54.28	0.25	54.03	0.5
		CT/T	54.16	0.23	53.93	0.4
	PP	UD	54.16	0.23	53.93	0.4
		CT	53.86	0.12	53.74	0.2
		CT/T	53.74	0.11	53.63	0.2
	CP	UD	50.73	0.11	50.62	0.2
		CT	50.43	0.06	50.37	0.1
		CT/T	50.31	0.05	50.26	0.1
W-M-M-M	Con	UD	47.58	0.13	47.45	0.3
		CT	47.39	0.06	47.33	0.1
		CT/T	47.32	0.05	47.27	0.1
	PP	UD	47.32	0.12	47.20	0.3
		CT	47.13	0.05	47.08	0.1
		CT/T	47.06	0.04	47.02	0.1
	CP	UD	46.16	0.08	46.08	0.2
		CT	45.98	0.04	45.94	0.1
		CT/T	45.91	0.03	45.88	0.1

[a]Con = conventional tillage, PP = plow-plant tillage, and CP = chisel-plow tillage.
[b]UD = up-and-down cultivation, CT = contouring, and CT/T = contouring and terracing.
[c]Net of nonland costs, weighted average for the subwatershed cropland.
[d]As computed by using the procedure discussed in the text.
[e]Column 3 minus column 4.

Net social income does not follow the same pattern as net income. The highest net social income occurs with continuous corn, conventional tillage, and contouring or contouring and terracing ($81.34), whereas the highest net income occurs with the same rotation and tillage system but with up-and-down cultivation ($83.77). This pattern is repeated with all the intensive row crop rotations, from continuous corn to C-Sb-C-W-M (excepting C-Sb-C-Wx), under all tillage systems.

With the C-W-M-M-M and W-M-M-M rotations, the highest net social income occurs under conventional tillage and up-and-down cultivation. Then the net social income gradually goes down as we move towards chisel-plow tillage with contouring and terracing. Although the difference between net social income under conventional tillage and that under plow-plant tillage is negligible, the difference under conventional and chisel-plow tillage is considerable, especially with the intensive row crop rotations (continuous corn through C-Sb-C-W-M), in which case it runs from about $11 to $17 per acre. The pattern is similar to that of net income before the cost of sediment damage is subtracted. However, had we used annualized net incomes for the 20-year planning period instead of for the single-year period in this evaluation, the range of differences might have been slightly narrowed. On the whole, except with the W-M-M-M rotation, the adoption of chisel-plow tillage appears undesirable because net social income is relatively low under this system compared with that under the other two tillage systems.

For specific subwatersheds, however, the relationships between crop combinations and sediment damage costs, as well as net social income levels, may vary considerably. Let us look at the results in the PC subwatershed as shown in Table 13. As we said earlier, the PC subwatershed represents an extreme case of high damage. The estimate of damage per acre reaches as high as $12.68 for the C-Sb rotation with conventional tillage and up-and-down cultivation. Except with the C-W-M-M-M and W-M-M-M rotations, the rate of sediment damage per acre under conventional tillage always exceeds $1.75. In most cases it is $3.50 or more.

Ninety percent or more of such damage is due to drainage ditch silting in the cropland area of the subwatershed (Table 11). With plow-plant tillage, the sediment damage rate is about half of that with conventional tillage. With chisel-plow tillage, the damage per acre is always below $1 except for the C-Sb rotation with up-and-down cultivation. For the C-W-M-M-M and W-M-M-M rotations, the damage cost per acre stays at or below $0.11.

Because of such wide variation in the sediment damage rates, we find some unexpected results in the net social income levels for the various crop rotation alternatives. For the intensive row crop rotations (continuous corn to C-Sb-C-S-M), the highest net social income is under plow-plant tillage with contouring or contouring and terracing and the second highest is under conventional tillage. Although net social income per acre is lowest under chisel-plow tillage, it generally comes close (within $3 to $4) to that under conventional tillage and up-and-down cultivation. In the case of the C-Sb rotation, the difference in net social income per acre between conventional tillage with up-and-down cultivation and chisel-plow tillage with up-and-down cultivation is only about $0.42. For the C-W-M-M-M and W-M-M-M rotations, the same relationship seems to exist between net social incomes per acre and the crop combinations as that found in the case of the whole UERB.

If we made a similar analysis of the SF subwatershed, which has a larger and relatively level drainage area and the lowest sediment damage levels in the UERB, we would probably find that net social income for the various crop combinations does not differ much from single-year net income. For this reason, such a subwatershed can be considered relatively safe from erosional hazards and devoid of any pronounced losses in productivity or in off-site damage.

ECONOMIC INCENTIVES FOR SOIL CONSERVATION

To gain further perspective on the erosion-sedimentation problem in the UERB, we need to compare sediment damages with the net farm income losses resulting from failure to control soil erosion. Furthermore, a comparison of the sum of productivity losses and sediment damage caused by erosion with net farm income itself will improve our judgment regarding the seriousness of the erosion-sedimentation problem and the magnitude of the task of designing an institutional system that will provide incentives to control erosion at a level acceptable to society. Regarding the long-run (20-year) productivity losses with various crop combinations for the whole UERB, we found that on the average this loss rarely exceeds $0.03 per acre and in most cases is near zero. With continuous row crops and up-and-down cultivation, this loss increases to $0.08 to $0.09 per acre. Even at this level, when expressed as a percentage of net income, this is only 0.1 percent. The same general relationship exists in the ERC, SF, BF, and LER subwatersheds. For the ERDT, PC, and KC subwatersheds, there is a $0.10 to $0.14 productivity loss per acre per year in the case of continuous row crops with conventional tillage and up-and-down cultivation. The percentage of the net income per acre is still about 0.2 percent. Therefore, on the whole, the question of productivity loss over the course of time is not considered significant in the UERB. As we showed earlier, the loss of net land rent is very small.

We are left, then, with sediment damage as a significant concern. As before, we examined this issue for the whole UERB (Table 12) and for the PC subwatershed (Table 13). On the left-hand side of both tables are 63 combinations of crop rotations, conservation practices, and tillage systems. Let us look first at Table 12. If we assume that farmers have no knowledge at all about the annual sediment damages, then the most profitable combination is obviously continuous corn with conventional tillage and up-and-down cultivation. Earlier, we concluded that farm productivity losses and the land rent loss are not matters of significant concern in this watershed. This is not true, however, of sediment damage, which, expressed as a percentage of net income, ranges from 0.1 to 4.6 percent (col. 6). The amount of sediment damage is enough that, if the farmers were to include its cost in their operational costs, their decision regarding the most profitable combination could well be altered. For example, in the case of continuous corn with conventional tillage and up-and-down cultivation, inclusion of sediment damage would lower the net income per acre to a point slightly below that with contouring or contouring and terracing. Shifting to plow-plant tillage would lower net income a little more and shifting to chisel-plow tillage would be disastrous, resulting in a large loss of net income. To be sure, sediment damage rates go down considerably with the chisel plow, but so do yields of row and grain crops, approximately 5 to 15 percent. This situation is quite unlike that in the southern Illinois watersheds studied [5 and 7], where the use of the chisel plow increases both yield and net income.

However, when we look at Table 13, which shows results for the PC subwatershed, we find many deviations from the situation in the UERB as a whole. Sediment damage expressed as a percentage of net income per acre is as high as 16 percent. The intensive row crop rotations under conventional tillage always show the highest damage percentages. These percentages are so high that inclusion of sediment damage in the cost of operations changes the most profitable combination from continuous corn, conventional tillage, and up-and-down cultivation to continuous corn, plow-plant tillage, and contouring and terracing, necessitating a shift in the tillage system as well as in the conservation practice. If sediment damages are considered for this particular subwatershed, we do see strong economic incentives for drastic changes in tillage and conservation systems. It is clear from the analysis, however, that the most profitable combination of crop rotation, tillage system, and conservation practice determined for the whole of the UERB as a unit could differ from that for an individual subwatershed. In the case of the PC subwatershed, it is obvious that higher net social incomes are possible with plow-plant tillage. It is also likely that, in the case of another subwatershed, switching to plow-plant tillage would lead to a loss of net income (for example, in the SF subwatershed). Such differences occur mainly because of the wide variations in damage costs among subwatersheds for various crop alternatives (Table 11).

In the final analysis, it seems advantageous to calculate net income, sediment damage, and net social income by individual subwatersheds so that the variations in damage levels can be considered and the most profitable crop alternative for each subwatershed correctly identified.

The alternatives of (1) a charge or a tax to be paid by the farmer for his sediment discharge or (2) cost share payments to the farmer for erosion control operations in order to encourage him to take sediment damage into account as discussed in the previous reports [4, 5, 7, 8] are relevant also, but they, too, should be considered in relation to the individual subwatersheds.

APPENDIX 1. NAMES OF SOIL TYPES IN THE UERB

S.No.	Soil type number	Soil type name
1	24	Dodge Silt Loam
2	25	Hennepin Loam
3	27	Miami Silt Loam
4	55	Sidell Silt Loam
5	56	Dana Silt Loam
6	59	Lisbon Silt Loam
7	60	LaRose Silt Loam
8	67	Harpster Silty Clay Loam
9	69	Milford Silty Clay Loam
10	76	Otter Silt Loam
11	104	Virgil Silt Loam
12	107	Sawmill Silty Clay Loam
13	120	Huey Silt Loam
14	126	Bonpus Silty Clay Loam
15	131	Alvin Fine Sandy Loam
16	132	Starks Silt Loam
17	134	Camden Silt Loam
18	142	Patton Silty Clay Loam
19	145	Saybrook Silt Loam
20	148	Proctor Silt Loam
21	149	Brenton Silt Loam
22	152	Drummer Silty Clay Loam
23	153	Pella Silty Clay Loam
24	154	Flanagan Silt Loam
25	171	Catlin Silt Loam
26	189	Martinton Silt Loam
27	198	Elburn Silt Loam
28	199	Plano Silt Loam
29	206	Thorp Silt Loam
30	207	Ward Silt Loam
31	208	Sexton Silt Loam
32	219	Millbrook Silt Loam
33	224	Strawn Silt Loam
34	233	Birkbeck Silt Loam
35	234	Sunbury Silt Loam
36	236	Savina Silt Loam
37	291	Xenia Silt Loam
38	293	Andres Silt Loam
39	295	Mokena Silt Loam
40	322	Russell Silt Loam
41	328	Cullo Silt Loam
42	330	Peotone Silty Clay Loam
43	330A	Peotone Silty Clay Loam (Wet)
44	333	Wakeland Silt Loam
45	348	Wingate Silt Loam
46	353	Toronto Silt Loam
47	355	Esmen Silt Loam
48	451	Lawson Silt Loam
49	465	Montgomery Silt Loam
50	481	Raub Silt Loam
51	496	Fincastle Silt Loam
52	497	Mellott Silt Loam

APPENDIX 2. SOIL TYPE ACREAGES IN THE UERB (BY SUBWATERSHEDS)

Soil type[a]	Soil S/E[b]	Soil area[c]
Embarras River Direct Tributary		
25	G2	2981.
27	C1	0.
27	C3	308.
27	D2	154.
27	D3	103.
27	E2	514.
27	F2	1234.
56	B1	257.
69	A0	5397.
107	A0	925.
126	A0	2364.
131	B1	51.
132	A1	565.
134	B1	771.
134	C1	514.
134	C2	51.
134	D3	668.
142	A0	1079.
148	B1	154.
145	B2	360.
149	A1	617.
152	A0	28938.
153	A0	154.
154	A1	11411.
154	A1	565.
171	B1	1388.
171	C1	154.
198	A1	977.
206	A0	103.
207	A0	1234.
208	A0	257.
219	A1	51.
224	D2	411.
224	D3	308.
224	D3	462.
224	E3	977.
224	F2	3341.
224	F3	462.
224	G2	10023.
224	G3	3547.
233	B1	1542.
236	A1	4369.
236	B1	154.
291	A1	925.
291	B1	9149.
291	B2	874.
291	C2	1388.
293	B1	51.
295	A1	154.
322	C1	411.
322	C2	3495.
322	C3	822.
322	D1	257.
322	D2	977.
322	D3	463.
322	E2	251.
333	A0	617.
348	B1	822.
353	A1	874.
355	B1	206.
355	B1	206.
451	A0	3804.
465	A0	2056.
481	A1	4780.
481	B1	1028.
496	A1	5757.
496	B1	5039.
496	B2	103
Embarras River above Camargo		
24	C1	1184.
24	C2	113.
24	D2	395.
55	B1	56.
56	B1	1466.
56	C1	169.
56	C2	113.
59	A1	226.
60	C2	56.
67	A0	2087.
104	A0	338.
134	B1	395.
145	B1	338.
145	B2	113.
148	A1	56.
148	B1	508.
148	B2	226.
149	A1	2030.
149	B1	169.
152	A0	47319.
152	A0	338.
154	A1	21939.
154	B1	8121.
171	A1	282.
171	B1	1353.
198	A1	6486.
198	B1	1410.
199	B1	1128.
206	A0	1015.
207	A0	56.
224	D2	1072.
224	F2	282.
224	G2	169.
234	A1	282.
236	A1	338.
236	B1	113.
291	B1	1748.
291	C1	790.
322	C2	1354.
328	A0	338.
330	A0	282.
353	A1	113.
451	A0	226.
451	A9	1579.
481	B1	226.
496	A1	508.
496	B1	226.
Scattering Fork		
69	A0	12859.
126	A0	1251.
149	A1	1181.
152	A0	29124.
154	A1	15361.
154	B1	3336.
171	B1	139.
189	A1	2571.
198	A1	1668.
206	A0	278.
293	A1	278.
465	A0	2988.
Brushy Fork		
55	C1	98.
56	B1	3473.
56	C1	538.
59	A1	98.
59	B1	196.
67	A0	391.
69	A0	8072.
76	A0	98.
120	A0	2040.
126	A0	2446.
142	A0	342.
145	B1	294.
145	C2	196.
148	B1	1076.
149	A1	5576.
149	B1	147.
152	A0	30575.
152	A9	98.
154	B1	1712.
171	B1	1027.
189	A1	345.
198	A1	5674.
198	B1	2152.
199	B1	489.
199	C1	49.
199	C2	440.
295	A1	1223.
295	B1	1565.
295	C2	342.
295	C3	342.
330	A0	1418.
465	A0	10126.
481	A1	5822.
481	B1	1320.
Little Embarras River		
27	E3	61.
55	B1	183.
55	C2	244.
56	B1	3228.
148	A1	183.
149	A1	2802.
149	B1	487.
152	A0	48788.
154	A1	16080.
154	B1	1523.
171	B1	2923.
234	A1	609.
236	A1	670.
291	B1	244.
291	B2	122.
330A	A0	122.
353	A1	2436.
353	B1	244.
481	A1	1705.
481	B1	1400.
496	A1	365.
496	B1	61.
497	B1	122.
Polecat Creek		
27	C3	191.
27	D2	64.
27	E2	32.
27	E2	32.
27	F2	95.
27	F2	191.
27	F2	382.
152	A0	191.
224	G2	2130.
291	B1	477.
322	C1	95.
322	C2	95.
322	C2	64.
322	C2	95.
322	C2	254.
322	C3	32.
322	D1	127.
322	D2	64.
322	D3	127.
322	E2	32.
333	A0	159.
333	A0	127.
56	B1	64.
56	B1	382.
152	A0	413.

See footnotes on next page.

APPENDIX 2. (CONTINUED)

Soil type[a]	Soil S/E[b]	Soil area[c]	Soil type[a]	Soil S/E[b]	Soil area[c]	Soil type[a]	Soil S/E[b]	Soil area[c]	Soil type[a]	Soil S/E[b]	Soil area[c]
152	A0	954.	330A	A0	64.	27	E2	310.	224	G2	2107.
154	A1	350.	56	B1	1208.	27	E3	62.	233	A1	744.
154	A1	32.	152	A0	32.	55	B1	1797.	233	B1	2851.
348	B1	636.	152	A0	1431.	55	C2	1054.	236	A1	6508.
348	B1	350.	152	A0	636.	56	B1	1674.	291	A1	124.
348	C2	32.	481	A1	541.	56	C2	186.	291	B1	2355.
348	C2	32.	481	A1	64.	134	B1	124.	291	C1	310.
353	A1	254.	481	A1	32.	152	A0	16858.	291	C2	124.
353	A1	32.	481	A1	254.	154	A1	4463.	322	C2	1488.
55	B1	95.	481	B1	572.	154	B1	1239.	322	C3	248.
55	C2	127.	481	B1	127.	171	B1	1735.	322	D2	186.
56	B1	477.	481	B1	32.	198	A1	372.	322	E2	310.
152	A0	2035.				206	A0	248.	451	A0	8925.
154	A1	477.	Kickapoo Creek			207	A0	310.	481	A1	1054.
154	B1	127.				224	C2	558.	481	B1	1488.
171	B1	95.	27	D2	372.	224	E2	620.	496	A1	1054.
171	B1	145.	27	D3	310.	224	F2	4277.	496	B1	248.

[a]Refers to soil type by number. For names, see Appendix 1.
[b]S = slope percentage and E = erosion class; letters A to G designate slope percentages, where A = 0-2, B = 2-4, C = 4-7, D = 7-12, E = 12-18, F = 18-30, and G = over 30; and numbers 1 to 3 designate erosion classes, where 1 = more than 7 inches of topsoil remaining, 2 = 3-7 inches of topsoil remaining, and 3 = 0-3 inches of topsoil remaining.
[c]Area in acres.

APPENDIX 3. PRESENCE OF DRUMMER AND FLANAGAN SOILS (PERCENTAGE) IN THE CROPLAND AREAS OF THE UERB

Subwatersheds	Percentage
1. Embarras River Direct Tributary	37
2. Embarras River above Camargo	72
3. Scattering Fork	67
4. Brushy Fork	36
5. Little Embarras River	79
6. Polecat Creek	50
7. Kickapoo Creek	44

APPENDIX 4. LAND USE IN THE SUBWATERSHEDS BASED ON SAMPLE TRACTS FROM CNI [1] (AREA IN ACRES)

Embarras River Direct Tributary

Land use	Slope classes A (0-2%)	B (2-4%)	C (4-7%)	D (7-12%)	E (12-18%)	F (18-30%)	G (over 30%)	Total
Row crops	1,051	203	44	10	0	0	1	1,309
Small grains	210	53	13	1	1	1	0	279
Rotation pasture and meadow	63	39	31	4	0	0	0	137
Orchard	0	0	0	0	0	0	0	0
Pasture	72	80	35	22	11	7	8	235
Forest and woodland	56	45	25	22	31	87	310	576
Other	54	19	4	6	0	3	3	86
Total sampled area	1,506	439	152	65	43	98	322	2,622

Embarras River above Camargo

Row crops	1,182	203	8	3	0	0	0	1,396
Small grains	155	31	4	0	0	0	0	190
Rotation pasture and meadow	150	51	18	1	0	0	0	220
Orchard	0	0	0	0	0	0	0	0
Pasture	21	16	24	15	0	3	2	81
Forest and woodland	21	0	1	3	0	2	2	29
Other	30	19	12	4	0	0	0	65
Total sampled area	1,561	321	67	26	0	5	3	1,981

Scattering Fork

Row crops	226	41	0	0	0	0	0	767
Small grains	237	9	0	0	0	0	0	246
Rotation pasture and meadow	0	0	0	0	0	0	0	0
Orchard	0	0	0	0	0	0	0	0
Pasture	3	0	0	0	0	0	0	3
Forest and woodland	0	0	0	0	0	0	0	0
Other	6	0	0	0	0	0	0	6
Total sampled area	972	50	0	0	0	0	0	1,022

Brushy Fork

Row crops	1,031	154	21	0	0	0	0	1,206
Small grains	404	46	1	0	0	0	0	451
Rotation pasture and meadow	95	26	3	0	0	0	0	124
Orchard	0	0	0	0	0	0	0	0
Pasture	60	30	15	0	0	0	0	105
Forest and woodland	0	0	0	0	0	0	0	0
Other	34	19	1	0	0	0	0	54
Total sampled area	1,624	275	41	0	0	0	0	1,940

APPENDIX 4. (CONTINUED)

Little Embarras River

Land use	Slope classes A (0-2%)	B (2-4%)	C (4-7%)	D (7-12%)	E (12-18%)	F (18-30%)	G (over 30%)	Total
Row crops	1,035	143	4	0	0	0	0	1,182
Small grains	81	16	0	0	0	0	0	97
Rotation pasture and meadow	78	2	0	0	1	0	0	81
Orchard	2	4	0	0	0	0	0	6
Pasture	1	2	0	0	0	0	0	3
Forest and woodland	0	0	0	0	0	0	0	0
Other	14	6	0	0	0	0	0	20
Total sampled area	1,211	173	4	0	1	0	0	1,389

Polecat Creek

Row crops	158	124	13	0	0	0	0	295
Small grains	34	28	10	0	1	0	0	73
Rotation pasture and meadow	49	32	1	0	0	0	0	82
Orchard	2	4	0	0	0	0	0	6
Pasture	5	0	3	4	1	0	0	13
Forest and woodland	0	0	3	8	1	18	67	97
Other	6	3	2	0	0	3	0	14
Total sampled area	254	191	32	12	3	21	67	580

Kickapoo Creek

Row crops	403	135	28	2	0	2	0	570
Small grains	72	21	3	0	0	0	0	106
Rotation pasture and meadow	43	13	6	4	1	0	0	67
Orchard	0	1	0	0	0	0	0	1
Pasture	83	28	12	1	20	2	30	176
Forest and woodland	13	2	14	6	0	58	4	97
Other	42	8	1	1	0	7	0	59
Total sampled area	656	218	64	14	21	69	34	1,076

REFERENCES

1. Illinois Conservation Needs Committee, *Soil and Water Conservation Needs Inventory*, Cooperative Extension Service, College of Agriculture, University of Illinois at Urbana-Champaign, 1970.

2. Illinois Crop Reporting Service, Illinois Department of Agriculture, and U.S. Department of Agriculture, *Illinois Agricultural Statistics, Annual Summary 1972*, Springfield, Illinois, 1972.

3. Illinois State Water Survey, *The Silting of Lake Springfield*, Report of Investigation 16, Urbana, Illinois, 1952.

4. Lee, M.T., *et al.*, *Economic Analysis of Erosion and Sedimentation, Hambaugh-Martin Watershed*, Department of Agricultural Economics, and Agricultural Experiment Station, University of Illinois at Urbana-Champaign, AERR 127, 1974.

5. _____, *Economic Analysis of Erosion and Sedimentation, Sevenmile Creek Watershed*, Department of Agricultural Economics, and Agricultural Experiment Station, University of Illinois at Urbana-Champaign, AERR 130, 1974.

6. Mausel, P.W., E.C.A. Runge, and S.G. Carmer, *Use of Sample and Seventh Approximation Criteria in Delineating Areas of Similar Soils*, Proceedings of Soil Science Society 34:657-662.

7. Narayanan, A.V.S., *et al.*, *Economic Analysis of Erosion and Sedimentation, Crab Orchard Lake Watershed*, Department of Agricultural Economics, and Agricultural Experiment Station, University of Illinois at Urbana-Champaign, AERR 128, 1974.

8. _____, *Economic Analysis of Erosion and Sedimentation, Mendota West Fork Watershed*, Department of Agricultural Economics, and Agricultural Experiment Station, University of Illinois at Urbana-Champaign, AERR 126, 1974.

9. Nelson, T.F., "A Method of Determining the Reduction in Sediment Yield at the Mouth of P.L. 566 Watershed," Technical Note, Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C., 1972.

10. Odell, R.T., and W.R. Oschwald, *Productivity of Illinois Soils*, Circular 1016, Cooperative Extension Service, College of Agriculture, University of Illinois at Urbana-Champaign, 1970.

11. Reiss, F.J., *Landlord and Tenant Shares 1972*, Department of Agricultural Economics, and Agricultural Experiment Station, University of Illinois at Urbana-Champaign, 1973.

12. UMRCBS Coordinating Committee, *Upper Mississippi River Comprehensive Basin Study*, Vol. III, Appendix G: "Fluvial Sediment," U.S. Army Engineer District, Chicago, Illinois, 1970.

13. U.S. Army Corps of Engineers, *General Design Memorandum Lincoln Lake*, U.S. Army Corps of Engineers, Louisville District, Louisville, Kentucky, 1971.

14. USDA Soil Conservation Service, *Resource Conservation Planning, Erosion in Illinois--Amount by Counties*, Technical Note IL-3, Champaign, Illinois, 1973.

15. USDA Soil Conservation Service, *Scattering Fork Watershed--Work Plan*, rev. ed., Champaign, Douglas, and Coles Counties, Illinois, Champaign, Illinois, 1969.

16. _____, *Universal Soil Loss Equation*, Agronomy Technical Note, Champaign, Illinois, 1970.

17. Wischmeir, W.H., and D.D. Smith, *Predicting Rainfall Erosion Losses from Cropland East of Rocky Mountains*, Agricultural Handbook 282, U.S. Department of Agriculture, Washington, D.C., 1961.